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EXPERIMENTAL INVESTIGATION AND OPTIMIZTION OF WELDING PARAMETERS OF METAL INERT GAS WELDING PROCESS IN JOINING DISSIMILAR METALS

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ABSTRACT

The erection and production industries of modern world use dissimilar metals for different parts that are primarily joined using numerous welding processes. Metal Inert Gas welding has a wider application in the manufacturing sectors. As such in machining, optimization of welding parameters must be done to increase the productivity and maintain excellent weld strength. The welding strength which is a function of hardness of the joint is major criteria that determine the life of the welded joints. AISI 1045 alloy steel and High Chromium high carbon steel was welded. Welding current, voltage and the pressure of the inert gas are varied with welding time and hardness of the weld being the responses. Grey Relational Analysis has been used to identify the most feasible combination of parameters based on the Grey Relational Grade where it converts the original values into reference values. The suitable welding parameters were found to be 26 volts of voltage, 200 amperes of welding current and 6 bar of pressure. Technique for order of preference by similarity to ideal solution has shown that the optimal solution based on the preference number is 22 Volts, 150 amperes and 4 bar.

KEYWORDS: Welding strength, Hardness, TOPSIS, Grey Relational Analysis & Metal Inert Gas welding.

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Original Article

INTRODUCTION

Modern firms develop high strength joints by introducing numerous material combinations to improve the life and efficiency of the joint. One such has been made in this work, where AISI 1045 alloy steel has been welded with High chromium high carbon steel by adopting full factorial method for different combinations of the welding parameters to determine the best possible combination of parameters.

Abbasi. K. Alam S and Dr. Khan M.I (2012) exposed that the penetration depth increases with increase in welding speed and heat input upto 1450 mm/min and 109 J/min and beyond which penetration depth and shape factor decreases. Biswajit Das, Debbarma B, Rai R. N and Saha S. C. (2013) proved that the penetration depth suddenly increases at maximum voltage, current and at higher welding speed the penetration depth decreases. Abbasi. K, Alam. S and Khan. M. I. (2011) increased the pressure of the inert gas that increased the voltage in order to maintain good bead shape and use of Argon/CO mixture can resist a pressure of 230 bars. Diganta Kalita and Parimal Bakul Barua (2014) optimized the welding parameters in welding C20 carbon steel and found that welding current as the most significant parameter for mean tensile strength. Also, welding voltage was found to be the most suitable parameter for mean and variation in tensile strength of the welded specimen with the tensile

strength at optimal parameters of 475.85 N/mm^2. Radhakrishnan et al (2017) analysed and optimized the parameters for electrical discharge machining process using Response surface Methodolgy. Mishra B, Panda R. R and Mohanta D. K. (2014) investigated the effect of welding parameters over penetration depth and optimized the same with Taguchi technique where the penetration depth was found to be 5.82 mm at the optimal combination of parameters. Nuraini. A. A, Zainal. A. S and Azmah Hanim. M. A (2014) studied the effect of current, voltage and travel speed on the strength of the weld, in welding of A1008 carbon steel base metal using robotic Metal Gas Arc Welding. Dinesh et al (2016) used Grey relational analysis for identifying the best feasible parameters for turning operation. Nur Azhani Abd Razakand Shing Shian Ng. (2014) analyzed the corrosion behavior of welded AISI 1010 carbon steel for various welding voltages and filler material. They inferred that a combination of higher welding voltage, heat treatment and usage of ER 308L filler material. Nabendu Ghosh, Pradip Kumar Pal and Goutam Nandi.(2016) identified that the welding current was the most influencing parameter in welding 316 L Austenitic steel and optimized the feasible set of parameters with Grey-Based Taguchi method. Pranesh B. Bamankar, Amol Chavan and Tushar Phadtare (2015) suggested that genetic algorithm and ant colony optimization techniques can be used in identifying the feasible combination of parameters. Prasenjit Mondal and Dipankar Bose (2015) developed a fuzzy model and optimized the best combination of welding parameters possible using Taguchi technique. The Multi Response Performance index was determined with the help of fuzzy interface. Rakesh Kumar and Satish Kumar (2014)identified that root gap had the highest degree of influence in tensile strength and welding voltage had the most significant effect on hardness on the specimen while welding mild steel 1018 material. The optimal parameters were found using Taguchi technique. Dinesh et al (2017) identified the most suitable combination of parameters for centerless grinding process using Taguchi – Grey relation method. Tripathy S and Tripathy D. K. (2016) used TOPSIS for optimizing the machining parameters for EDM process. Vineeta Kanwal and Jadoun R S (2015) clarified that the welding current had greater impact over hardness of the welded part and optimized the best combination of parameters using Taguchi technique. Kannan et al (2015) analyzed the impact of face milling parameters using RSM and GA. Deepan Bharathi Kannan et al (2014) and Suresh Kumar. B et al (2106) optimized the drilling parameters using Artificial Neural Network and framed the number of experiments by design of experiments. Godwin Antony et al (2017) used grey relational analysis to find the best possible parameters for blended diesel fed engine. Dinesh et al (2016) identified the number of experiments to be conducted using taguchi analysis for turning process.

EXPERIMENTATION

The table 1 shows the various levels of input welding parameters that have been used for experimentation. The full factorial design was used and 27 experiments were conducted with all the possible combination of parameters.

Figure 1: MIG Welding Machine

Figure 2: Rockwell Hardness Machine

The experimental reading for welding time and hardness was recorded. Rockwell hardness testing machine was used for testing under B scale as shown in figure 2. The MIG welding machine is shown in figure 1. Table 2 shows the experimental results. Plates were cut to 50 X 100 mm and welded.

Table 1: Levels of Welding Parameters

Parameters	Level 1	Level 2	Level 3
Voltage (volts)	22	24	26
Current (ampere)	150	175	200
Pressure (bar)	4	5	6

Table 2: Experimental Run

Trail number	Voltage (volts)	Current (ampere)	Pressure (bar)
1	22	150	4
2	22	175	4
3	22	200	4
4	24	150	4
5	24	175	4
6	24	200	4
7	26	150	4
8	26	175	4
9	26	200	4
10	22	150	5
11	22	175	5
12	22	200	5
13	24	150	5
14	24	175	5
15	24	200	5
16	26	150	5
17	26	175	5
18	26	200	5
19	22	150	6
20	22	175	6
21	22	200	6
22	24	150	6
23	24	175	6
24	24	200	6
25	26	150	6
26	26	175	6
27	26	200	6

Table 3: Experimental Results for Hardness and Welding Time

Trail number	Rockwell Hardness	Welding Time (sec)
1	62	45
2	52	38
3	70	33
4	38	39
5	55	32
6	27	37
7	32	30
8	50	29
9	56	30
10	62	40
11	45	33
12	33	32
13	26	38
14	74	34
15	48	36
16	65	40
17	44	49
18	72	32
19	42	38
20	43	35
21	27	36
22	59	42
23	39	37
24	42	41
25	62	33
26	60	34
27	66	27

RESULTS AND DISCUSSIONS

Grey Relational Analysis

The optimization was done using Grey relational analysis that normalize the responses. Table 4 shows the Grey relational grades and rank for all 27 experiments. The trail number 14 has the maximum Grey relational grade and trail number had the least. The optimized levels of the experimentation has been shown in table 5 based on the Grey relational grades.

Table 4: Grey Relational Grade (GRG)

Trail Number	GRG	RANK
1	0.523	15
2	0.511	18
3	0.757	4
4	0.440	23
5	0.623	8
6	0.431	25
7	0.576	11
8	0.675	6
9	0.679	5
10	0.559	12
11	0.550	13
12	0.528	14
13	0.417	26

Table 4: Contd.,		
14	0.806	1
15	0.513	17
16	0.588	10
17	0.387	27
18	0.805	2
19	0.463	21
20	0.508	19
21	0.445	22
22	0.522	16
23	0.466	20
24	0.433	24
25	0.653	7
26	0.621	9
27	0.875	3

Table 5: Optimized Results based on GRG

Paramters/ Levels	Voltage (volts)	Current (ampere)	Pressure (bars)
Level 1	5.15632	4.35246	4.64027
Level 2	4.74605	**5.82680**	5.13821
Level 3	**5.44971**	5.17281	**5.57359**

Figure 3 shows the optimized results of the process as 26 volts of voltage, 200 amperes of welding current and 6 bar of pressure.

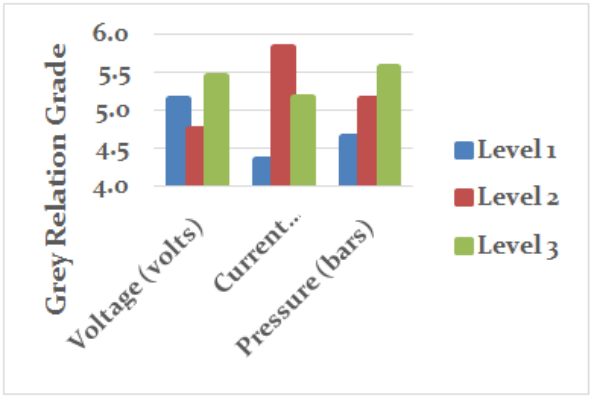

Figure 3: Optimized results

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

The preference number was at its peak in trail number 1 and was least at trail number 21. The maximum and the minimum preference value were recorded as 0.5997 and 0.3954. The most feasible set of parameters were identified as 22 Volts, 150 ampere and 4 bar. Table 6 shows the TOPSIS analyzed values.

Table 6: TOPSIS Analysis

Trail no	Positive Ideal Separation	Negative Ideal Separation	Relative Closeness	Order
1	0.048	0.072	0.5997	1
2	0.047	0.06	0.56	6
3	0.058	0.058	0.4999	18
4	0.067	0.061	0.4798	20

Table 6: Contd.,				
5	0.046	0.058	0.5582	7
6	0.09	0.059	0.3983	25
7	0.079	0.059	0.4301	24
8	0.049	0.06	0.5524	9
9	0.046	0.059	0.564	5
10	0.048	0.063	0.566	4
11	0.055	0.058	0.5139	15
12	0.077	0.058	0.4317	23
13	0.092	0.06	0.3961	26
14	0.065	0.058	0.4717	22
15	0.051	0.059	0.5351	13
16	0.051	0.063	0.5515	10
17	0.056	0.082	0.5928	2
18	0.061	0.058	0.487	19
19	0.06	0.06	0.5034	16
20	0.058	0.058	0.5014	17
21	0.09	0.059	0.3954	27
22	0.046	0.066	0.5874	3
23	0.065	0.059	0.4783	21
24	0.06	0.064	0.5196	14
25	0.048	0.058	0.5462	11
26	0.047	0.058	0.553	8
27	0.052	0.063	0.5462	12

CONCLUSIONS

The experiments were carried out and the optimization was done using Grey relational analysis and TOPSIS. The following findings have been recorded.

- The most feasible combination of parameters through GRA were found to be 26 volts of voltage, 200 amperes of welding current and 6 bar of pressure.
- The maximum Grey Relational Grade was recorded at the combination of 24 volts, 175 ampere and 5 bar.
- The minimum Grey relational grade was found at the combination of 26 volts, 175 ampere and 5 bar.
- The maximum and the least preference number, through TOPSIS were recorded as 0.5997 and 0.3954.
- The optimal solution based on the preference number is 22 Volts, 150 ampere and 4 bar based on TOPSIS.

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